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The effect of fluorine on reaction rim growth dynamics in the ternary CaO-MgO-SiO_2 system

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Growth of reaction rims is mainly controlled by a change in physical parameters such as pressure and temperature, a change in the chemical composition of the system and/or by the presence of volatiles. In particular, the effect of volatiles other than water on reaction rim growth remains poorly understood. In order to accurately model metamorphic and metasomatic processes, a quantification of the effect of volatiles on reaction-rim growth dynamics is necessary.

In this study, we investigated the effect of fluorine on reaction rim growth dynamics in the ternary CaO-MgO-SiO_2 system. A series of piston cylinder experiments were conducted at upper mantle P-T conditions of 1000 °C and 1.5 GPa. In each experiment, reaction rims were grown for 20 minutes between a natural wollastonite crystal and MgO powder matrix with the addition of up to 10 wt% fluorine.

Results show an increase in overall rim thickness from 12.50 (146) µm in the fluorine-free system to 105.49 (185) µm in experiments with a bulk fluorine content of 10 wt%. In the fluorine free system, we produced a rim sequence of wo | mer | di | fo | per, complying with phase stabilities at water saturated conditions. As soon as 0.1 wt% fluorine was introduced into the system, humite group minerals (HGMs) and monticellite were stabilized resulting in the multilayer rim sequence wo | mer | mon | fo + HGMs | per. In experiments with fluorine concentrations >1 wt%, cuspidine is stabilised and represents the major fluorine sink. Additionally, the transition from a monomineralic layer sequence to a palisade microstructure with alternating diopside and cuspidine lamellae at >1 wt% F suggests that fluorine affects the phase organisation within the reaction rim.

Our results illustrate the significance of fluorine during net-transfer reactions, where its presence changes phase stabilities and relative component mobilities. This implies not only that reaction rims may be used as a tool to infer the amount of fluorine present during metamorphic reactions, but also that we need to consider the role of fluorine for a correct interpretation of the P-T-t history of metamorphic rocks.